Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 10 November 2021 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[30 marks]**.

8821 – 6104

13 pages

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

8821–6104

1. What is the number of hydrogen atoms in 2.00 moles of $Ca(HCO_3)_2$?

Avogadro's constant, L or N_A: $6.02 \times 10^{23}\,mol^{-1}$

A. 2.00

B. 4.00

C. 1.20×10^{24}

D. 2.41×10^{24}

2. Which statement describes all homogeneous mixtures?

A. Any sample has the same ratio of the components.

B. The components are covalently bonded together.

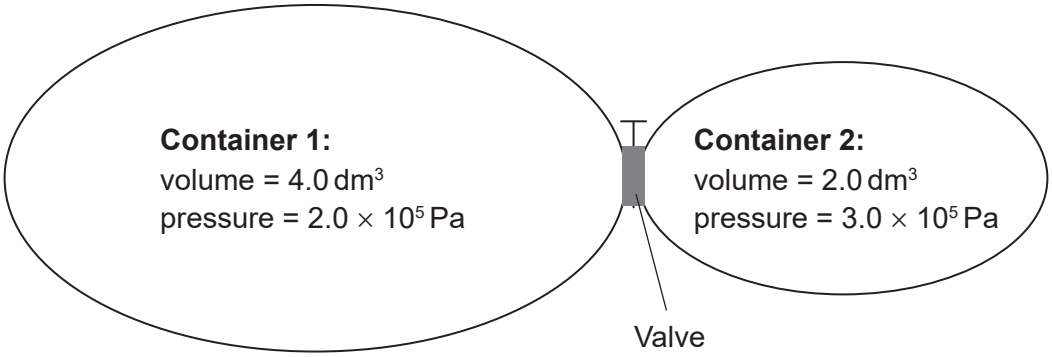
C. The components cannot be easily separated.

D. The mixture needs a specific ratio of components to form.

3. Which combination is correct?

	Structural formula	Empirical formula	IHD
A.	C_6H_{12}	C_2H_4	1
B.	C_6H_{14}	C_3H_7	0
C.	C_8H_8	CH	3
D.	C_8H_{10}	C_4H_6	4

4. The two containers shown are connected by a valve. What is the total pressure after the valve is opened and the two gas samples are allowed to mix at constant temperature?



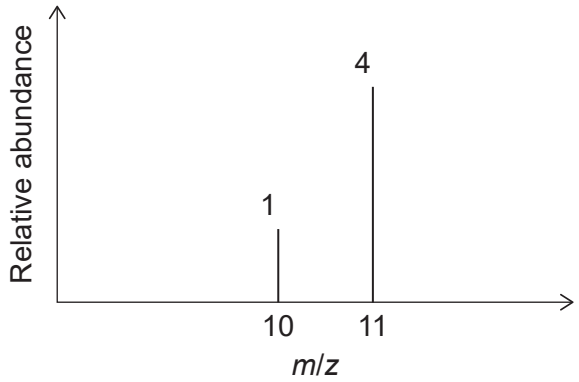
A. 1.5×10^5 Pa

B. 2.3×10^5 Pa

C. 2.5×10^5 Pa

D. 5.0×10^5 Pa

5. Consider the mass spectrum of an element:



What is the relative atomic mass of this element?

A. 10.2

B. 10.5

C. 10.8

D. 10.9

6. How many p-orbitals are occupied in a phosphorus atom?

A. 2

B. 3

C. 5

D. 6

7. Which element has the highest metallic character in Group 14?

A. C

B. Si

C. Ge

D. Sn

8. Which combination describes the acid–base nature of aluminium and phosphorus oxides?

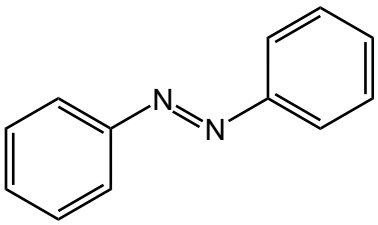
	Aluminium	**Phosphorus**
A.	Amphoteric oxide	Acidic oxide
B.	Basic oxide	Amphoteric oxide
C.	Acidic oxide	Amphoteric oxide
D.	Amphoteric oxide	Basic oxide

9. Which molecule has the **weakest** nitrogen to nitrogen bond?

A. N_2

B. N_2H_2

C. N_2H_4

D. 

10. Which combination would create the strongest ionic bond?

	Ionic radius	Charges on ions
A.	large	high
B.	large	low
C.	small	high
D.	small	low

11. Which compound contains both ionic and covalent bonds?

A. CH_3COONa

B. CH_3COOH

C. K_2O

D. $CaCl_2$

12. The following compounds have similar relative molecular masses. What is the order of increasing boiling point?

A. $CH_3CH_2CH_2OH < CH_3CH_2CHO < CH_3COOH$

B. $CH_3CH_2CHO < CH_3CH_2CH_2OH < CH_3COOH$

C. $CH_3CH_2CHO < CH_3COOH < CH_3CH_2CH_2OH$

D. $CH_3COOH < CH_3CH_2CHO < CH_3CH_2CH_2OH$

13. Which alcohol is **least** soluble in water?

A. CH_3OH

B. CH_3CH_2OH

C. $CH_3CH_2CH_2OH$

D. $CH_3CH_2CH_2CH_2OH$

14. Which combustion reaction releases the **least** energy per mole of C_3H_8?

	Approximate bond enthalpy / $kJ\,mol^{-1}$
O=O	500
C=O	800
C≡O	1000

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

B. $C_3H_8(g) + \frac{9}{2}O_2(g) \rightarrow 2CO_2(g) + CO(g) + 4H_2O(g)$

C. $C_3H_8(g) + 4O_2(g) \rightarrow CO_2(g) + 2CO(g) + 4H_2O(g)$

D. $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(g)$

15. Which equation represents the standard enthalpy of formation of lithium oxide?

A. $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

B. $2Li(s) + \frac{1}{2}O_2(g) \rightarrow Li_2O(s)$

C. $Li(s) + \frac{1}{4}O_2(g) \rightarrow \frac{1}{2}Li_2O(s)$

D. $Li(g) + \frac{1}{4}O_2(g) \rightarrow \frac{1}{2}Li_2O(g)$

16. Which statement describes an endothermic reaction?

A. The bonds broken are stronger than the bonds formed.

B. The enthalpy of the reactants is higher than the enthalpy of the products.

C. The temperature of the surroundings increases.

D. The products are more stable than the reactants.

17. Which instrument would best monitor the rate of this reaction?

$$2KI(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + I_2(aq)$$

A. Balance

B. Colorimeter

C. Volumetric flask

D. Gas syringe

18. Which combination has the greatest rate of reaction at room temperature?

	Zinc	$CuSO_4(aq)$
A.	1.00 g Zn powder	50.0 cm^3 of 0.200 mol dm^{-3} $CuSO_4(aq)$
B.	1.00 g Zn powder	100.0 cm^3 of 0.100 mol dm^{-3} $CuSO_4(aq)$
C.	1.00 g Zn strip	50.0 cm^3 of 0.200 mol dm^{-3} $CuSO_4(aq)$
D.	1.00 g Zn strip	100.0 cm^3 of 0.100 mol dm^{-3} $CuSO_4(aq)$

19. The equilibrium $2H_2(g) + N_2(g) \rightleftharpoons N_2H_4(g)$ has an equilibrium constant, *K,* at 150 °C.

What is the equilibrium constant at 150 °C, for the reverse reaction?

$$N_2H_4(g) \rightleftharpoons 2H_2(g) + N_2(g)$$

A. K

B. K^{-1}

C. $-K$

D. $2K$

20. Which ions are present in an aqueous solution of Na_2CO_3?

I. HCO_3^-

II. OH^-

III. CO_3^{2-}

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

21. What is the conjugate acid of HS^-?

A. H_2S

B. S^{2-}

C. H_2SO_3

D. H_2SO_4

22. What is the change in the oxidation state of oxygen?

$$2Fe^{2+}(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + 2Fe^{3+}(aq)$$

A. +1

B. 0

C. –1

D. –2

23. Which statement is correct about the electrolysis of molten lead(II) bromide, $PbBr_2$?

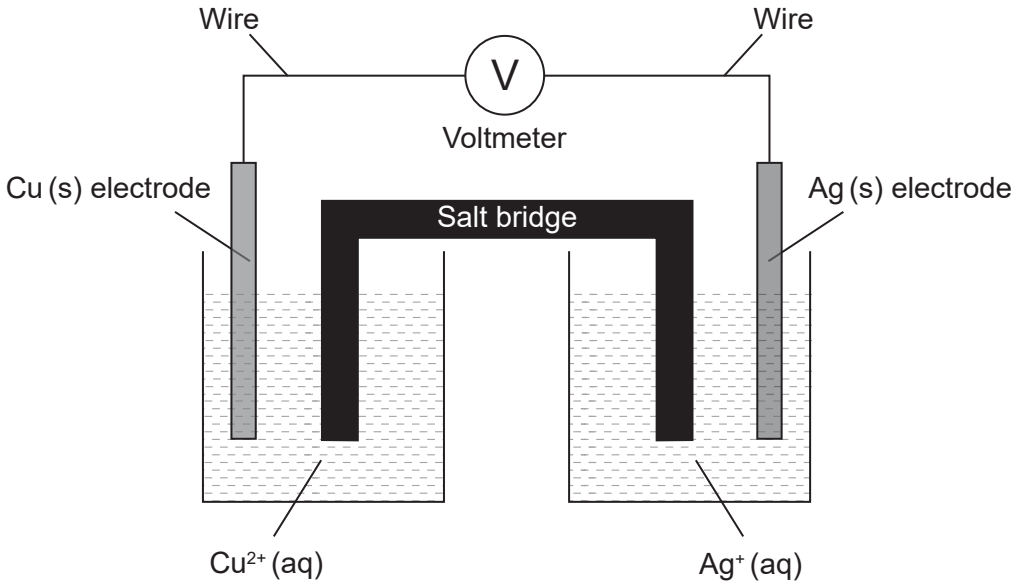
A. Br^- ions accept electrons at the cathode (negative electrode).

B. Pb^{2+} ions accept electrons at the anode (positive electrode).

C. Br^- ions lose electrons at the anode (positive electrode).

D. Pb^{2+} ions lose electrons at the cathode (negative electrode).

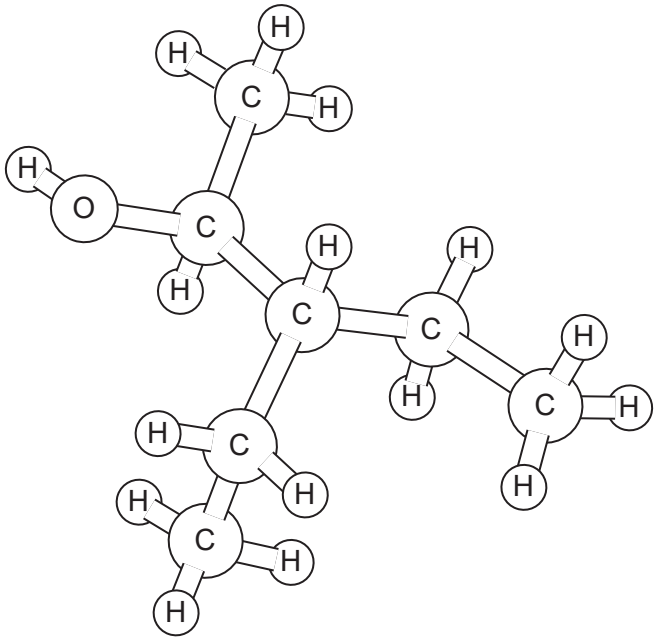
24. Consider this voltaic cell, where Cu is a more reactive metal than Ag:



Which combination describes the movement of charge in this cell?

	Flow of electrons in wire	**Flow of negative ions in salt bridge**
A.	Ag (s) to Cu (s)	Toward Ag^{+} (aq)
B.	Cu (s) to Ag (s)	Toward Ag^{+} (aq)
C.	Ag (s) to Cu (s)	Toward Cu^{2+} (aq)
D.	Cu (s) to Ag (s)	Toward Cu^{2+} (aq)

25. What is the name of this substance using IUPAC rules?



A. 2-ethyl-1-methylbutan-1-ol

B. 1-methyl-2-ethylbutan-1-ol

C. 3-ethylpentan-2-ol

D. 3-ethylpentan-4-ol

26. Which pair of compounds are structural isomers?

A. Propane and propene

B. Propanal and propanone

C. Propan-1-ol and propanal

D. Propyl propanoate and propanoic acid

27. What is the general formula of alkynes?

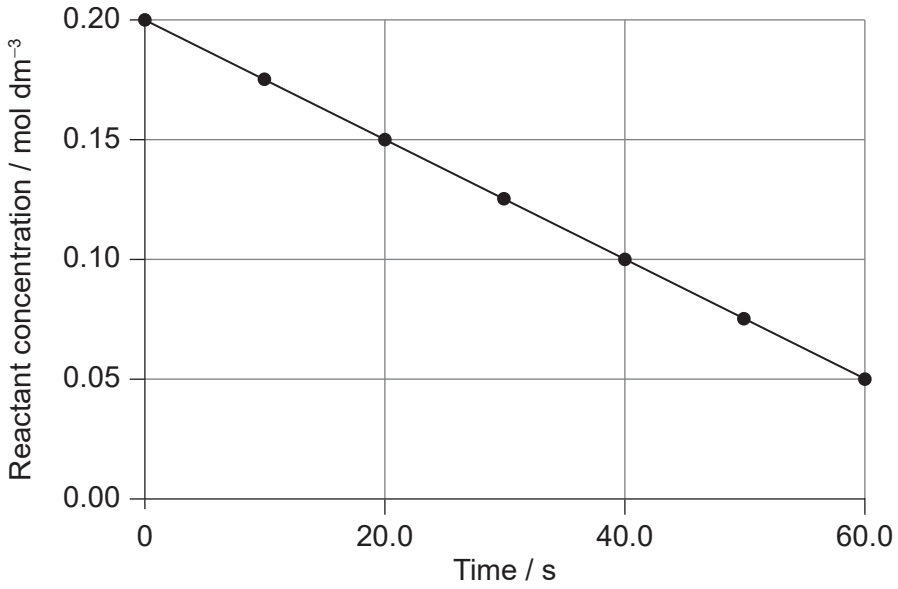
A. C_nH_{2n+2}

B. C_nH_{2n}

C. C_nH_{2n-2}

D. C_nH_n

28. What is the slope of the graph?



A. $-0.0025\,\text{mol}\,\text{dm}^{-3}\,\text{s}^{-1}$

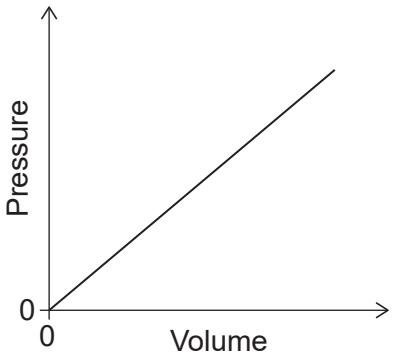
B. $-0.0025\,\text{mol}\,\text{dm}^{-3}\,\text{s}$

C. $-0.0033\,\text{mol}\,\text{dm}^{-3}\,\text{s}^{-1}$

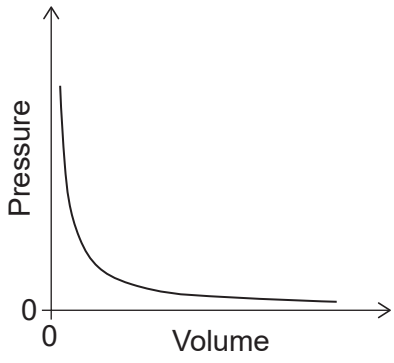
D. $-0.0033\,\text{mol}\,\text{dm}^{-3}\,\text{s}$

29. Which graph shows the relationship between the pressure and volume of a sample of gas at constant temperature?

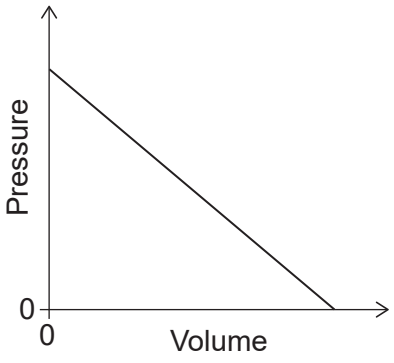
A.



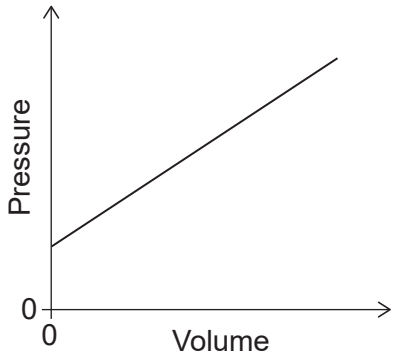
B.



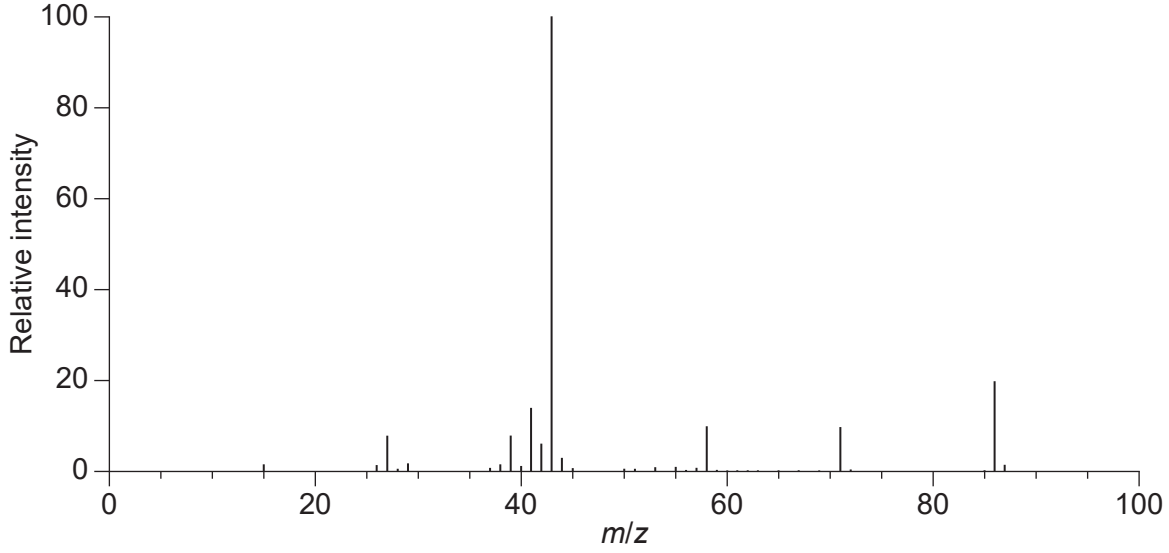
C.



D.



30. What can be deduced from the mass spectrum of $CH_3COCH_2CH_2CH_3$?



A. The molar mass is 43 g mol^{-1}.

B. The atoms have many isotopes.

C. The most likely bond to break is C–C between carbons 2 and 3.

D. The signal with the largest mass is due to the oxidation of the ketone in the spectrometer.

References:

14. Chemistry: Atoms First 2e, https://openstax.org/books/chemistry-atoms-first-2e/pages/9-4-strengths-of-ionic-and-covalent-bonds © 1999–2021, Rice University. Except where otherwise noted, textbooks on this site are licensed under a Creative Commons Attribution 4.0 International License. (CC BY 4.0) https://creativecommons.org/licenses/by/4.0/.

30. NIST Mass Spectrometry Data Center Collection © 2021 copyright by the U.S. Secretary of Commerce on behalf of the United States of America. All rights reserved. 2-Pentanone Mass Spectrum, MS Number 291264. [graph] Available at: https://webbook.nist.gov/cgi/cbook.cgi?ID=C107879&Units=SI&Mask=200#Mass-Spec2-pentanone [Accessed 4 May 2020]. Source adapted.